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PHYS 132L

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Lab 7: Series and Parallel Circuits

The goal of today's lab is to investigate series and parallel circuits. For each exercise you will build a circuit and predict the currents and voltages. You'll then measure the predicted quantities and compare predicted and measured values. Record all measurements to at least 3 significant figures and express all calculated quantities to 3 sig figs.

Using the Voltmeter and Ammeter:

Remember, voltmeters are connected in parallel with what is measured while ammeters are connected in series. When using an ammeter, you need to make a break in the circuit and then reconnect through the ammeter.

Preliminaries:

1) Choose 3 resistors between 33 and 100 ohms *each with different resistance values* from the component bins.
2) Measure the resistance of each resistor using the ohmmeter setting of the DVM (digital voltmeter). First select the "ohms" setting (200 ohms if you have a choice) and then connect the meter leads across the resistor you want to measure. These measured resistance values should be good to better than one percent; the manufacturers specified values are only guaranteed to 5%. Use these measured values for any calculations you do today.
3) You will use a variable power supply as a voltage source. Turn your supply on and adjust the voltage control so that the voltage reads about 5.0 volts. Set the current control to about ½ of its maximum. Switch the DVM setting back to volts, 20 volts full scale if you have the option, and measure the output voltage of your battery pack. Again, use this measured value in subsequent calculations.
4) In today's lab, you will calculate the % difference between your experimental finds and your theoretical predictions. To calculate % difference, use the formula:

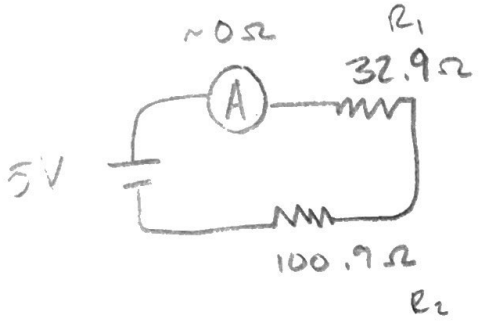
$$\%\ \text{difference} = \frac{(X_{th} - X_{exp})}{X_{th}} \times 100\%$$

Ohm's = theoretically

Series Circuit:

1) Choose two of your resistors and build a circuit with the resistors and the ammeter in series with the battery. Initially select the 500 mA scale for your ammeter. You probably can use a more sensitive setting after connecting your circuit. Do not make the final connection to the battery yet.
2) Draw a schematic of this circuit, labeling the values of all components.
3) Predict the values of current through and voltage across each resistor in the circuit: I_1, I_2, ΔV_1, and ΔV_2.
4) Make the final connection to the battery and measure the values predicted in (3). Choose the most sensitive ammeter setting that does not overload the meter. Also measure the voltage across the battery and the voltage across the ammeter. Find the percent difference between predicted and measured values.

(resistances)



Ammeter measures ~37mA

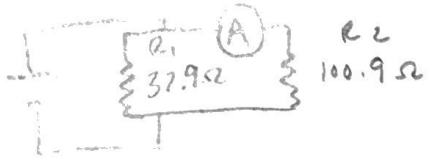
$$37 = \frac{5.09}{R} = 137.7\,\Omega$$

$$\frac{137.7 - 133.8}{137.7\,\Omega}$$

2.8% error

Parallel Circuit:

1) Select two of your resistors and build a parallel circuit. Again, wait to make the final battery connection.
2) Draw a schematic and predict all currents and voltages.
3) Make the final connection and measure the following: The battery voltage, the current through each resistor, the current through the battery, and the voltage drop across each resistor. Again, find the percent differences between the predicted and measured quantities. resistances



$\frac{1}{32.9} + \frac{1}{100.9} = \frac{1}{R_{eq}}$ $R_{eq} = 24.8\ \Omega$

$I_1 = .154$ A

$\Delta V_1 = 4.7$ V

$\frac{\Delta V}{I_1} = R = 30.5\ \Omega$ $\frac{30.5 - 32.9}{30.5}$ = 7.9% error in R_1

$I_2 = .049$ A

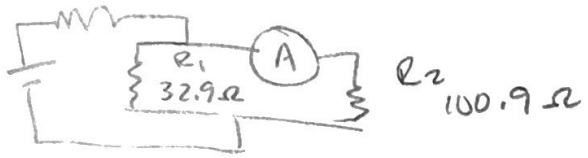
$\Delta V_2 = 4.9$ V

$\frac{\Delta V_2}{I_2} = R_2 = 100\ \Omega$ $\frac{100 - 100.9}{100}$ = .9% error

Series Parallel Combination:

1) Now make a circuit using 3 resistors: connect one resistor in *series* with the battery and the other two in *parallel* with each other. Hold off on making the final battery connection. Sketch and label a circuit diagram.
2) After predicting the voltage drop across each resistor, connect the circuit and measure the three voltages. Find the percent difference between predicted and measured voltages. resistances

R_3
100.2 Ω



R_2

$I_2 = 9.$ mA

$\Delta V_2 = .98$ V

$I_2 = \frac{\Delta V_2}{R_2} = 109.8\,\Omega$

$\frac{109.8\,\Omega - 100.9}{109.8} = 7.3\%$ error on R_2

R_1

$I_1 = 25$ mA

$\Delta V_1 = .96$ V

$I_1 = \frac{\Delta V_1}{R_1} = 38.4\,\Omega$

$\frac{38.4 - 32.9}{38.4} = 14.3\%$ error on R_1

R_3

$I_3 = 35.5$ A

$\Delta V_3 = 4$

$I_3 = \frac{\Delta V_3}{R_3} = 112.7\,\Omega$

$\frac{112.7 - 100.2}{112.7} = 11.1\%$ error on R_3

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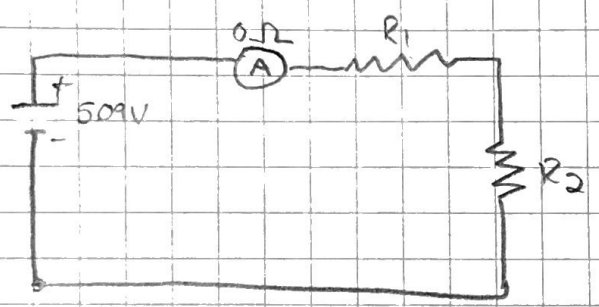
Physics

$R_1 = 32.9\ \Omega$
$R_2 = 100.9\ \Omega$
$R_3 = 100.2\ \Omega$
$\Delta V = 5.09\ V$

$$\Delta\% = \frac{(X_{th} - X_{exp})}{X_{th}} \times 100\%$$

Series circuit



$R_1 = 32.9\ \Omega$
$R_2 = 100.9\ \Omega$

$R_{eq} = 133.8\ \Omega$

$I = \frac{\Delta V}{R}$

$I(133.8\ \Omega) = 5.09\ V$

$I = 0.039\ A$ X_{exp}

Calculated values

$I_1 = \frac{\Delta V}{R_1}$ $I_2 = \frac{\Delta V}{R_2}$

$\Delta V = 5.09\ V$ $\Delta V = 5.09\ V$

$R_1 = 32.9\ \Omega$ ✓ $R_2 = 100.9\ \Omega$ ✓

$I_1 = 0.155\ A$ $I_2 = 0.05\ A$

$\Delta V_1 = 5.09\ V$ $\Delta V_2 = 5.09\ V$

Measured Values

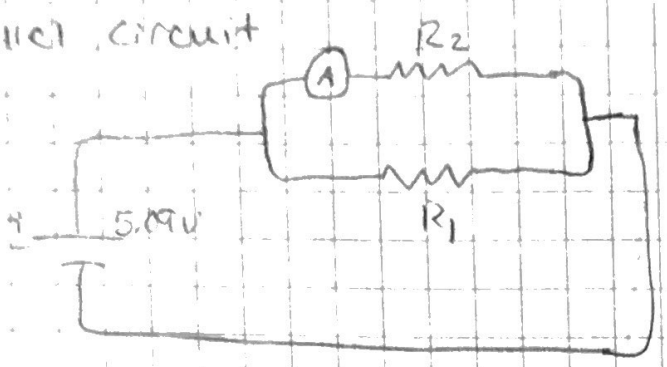
$I = 37\ mA$ $R = \frac{\Delta V}{I}$: $R = \frac{5.09\ V}{37\ mA}$

$\Delta V = 5.09$ $R = 137.568\ \Omega$ X_{th}

$$\left(\frac{137.568\ \Omega - 133.8\ \Omega}{137.568\ \Omega}\right) \times 100$$ ✓

2.7% ✓

Parallel circuit



$R_1 = 32.9$

$R_2 = 100.9$

$\frac{1}{R_{eq}} = \left(\frac{1}{32.9\Omega} + \frac{1}{100.9\Omega}\right)$

$R_{eq} = 24.81\ \Omega$

$I = \frac{\Delta V}{R}$ $\quad 5.09V = I(24.81\Omega)$

$I = 0.205A$

R_1: $I_1 = \frac{\Delta V_1}{R_1}$ $\quad R_1 = \frac{\Delta V_1}{I_1}$

$\Delta V_1 = 4.7V$

$I_1 = 0.154A$ $\quad R_1 = 30.51\ \Omega$

$\frac{30.51\Omega - 32.9\Omega}{30.51\Omega} \times 100$

7.8%

R_2: $I_2 = \frac{\Delta V_2}{R_2}$ $\quad R_2 = \frac{\Delta V_2}{I_2}$

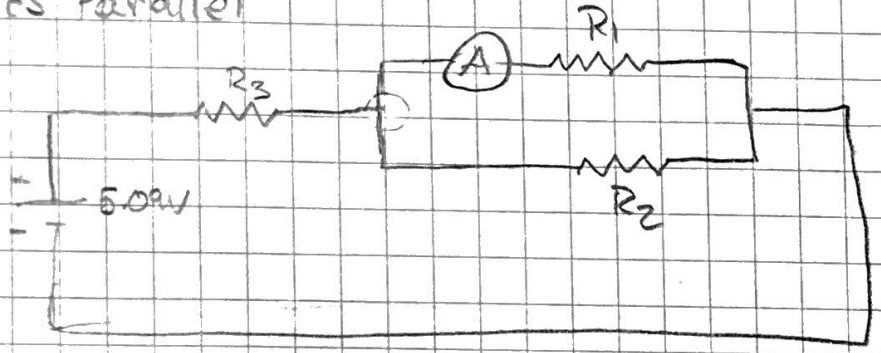
$\Delta V_2 = 4.9V$

$I_2 = 0.0499A$ $\quad R_2 = 100\ \Omega$

$\frac{100\Omega - 100.9\Omega}{100\Omega} \times 100$

0.9%

Series Parallel



$R_{eq} = R_1 + R_2$

$\frac{1}{R_{eq}} = \left(\frac{1}{32.9\Omega} + \frac{1}{100.9\Omega}\right)$

$R_{eq} = 24.81\ \Omega$

$I_2 = 0.009A$ $\quad R_2 = \frac{\Delta V_2}{I_2}$

$\Delta V_2 = 0.96V$ $\quad R_2 = 108.9\ \Omega$

$\left(\frac{108.9\Omega - 100.9\Omega}{108.9\Omega}\right) \times 100 = 7.34\%$

$I_1 = 0.025A$ $\quad R_1 = \frac{\Delta V_1}{I_1}$

$\Delta V_1 = 0.98V$

$R_1 = 38.4\ \Omega$

$\frac{(38.4\Omega - 32.9\Omega) \times 100}{38.4\Omega} = 14.32\%$

$I_3 = 0.0355A$ $\quad R_3 = \frac{\Delta V_3}{I_3}$

$\Delta V_3 = 4V$ $\quad R_3 = 112.6\ \Omega$

$\left(\frac{112.6\Omega - 100.2\Omega}{112.6\Omega}\right) \times 100 = 11.08\%$